US Army Corps of Engineers

Hydrologic Engineering Center

1999 Annual Report

Research

Technical Assistance

Training

Director's Comments

Top priorities for FY 1999 were our Corps Water Management System modernization software development and integration project, NexGen software research and development project, watershed and water resource system analysis, and comprehensive system studies. Progress was substantial in all these areas. Customer demand for HEC services and products continues to be high. Our reimbursable projects program continues strong, resulting in another fiscal high at year end. The professional staff remained relatively stable with just a few turnovers.

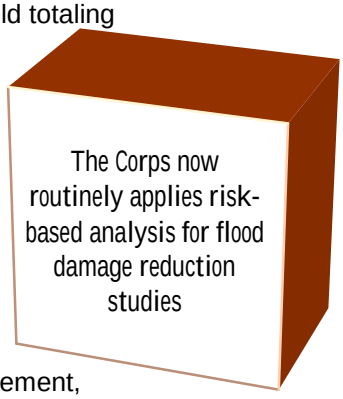
The project to modernize the Water Control Data System (WCDS) software began in FY 1997. Because the modernized system will be much more than a data system, it has been renamed to the Corps Water Management System (CWMS). CWMS is the decision support Automated Information Systems (AIS) that supports the Corps water management mission. It embodies data acquisition, validation, transformation and management; forecasting, simulation and decision support analysis; and information dissemination. Modernizing and deploying the corporate software for CWMS is a six year, $7.6 million centrally PRIP funded, Corps AIS improvement project managed under the Corps Life Cycle Management of Information Systems (LCMIS) process. The management structure and design teams form a unique arrangement for providing oversight and field participation in the enterprise-wide development and integration project. The significant accomplishment in FY 1999 was installation of Test Version 1.0 at four field sites. This is the first of two planned interim test installations prior to Test 3.0/CWMS Version 1.0, which will complete the system that will be deployed Corps-wide in 2001/2002. Project documents are available on the project Web site (http://cw71.cw-wc.usace.army.mil/cwcinfo/cwc.html). Test Version 2.0 is under development to be installed at selected field sites in mid-FY 2000.

The NexGen software research and development project continues at a brisk pace. The project is developing and fielding software tools to help Corps professionals perform their work better, more efficiently, and with increased ease. We now have released to field offices and the public, maiden release of the River Analysis System - HEC-RAS, followed by several major updates, the latest Version 2.2 is the final steady flow version; maiden Version 1.0 of the Hydrologic Modeling System - HEC-HMS and a bug fix update (Version 1.1); and maiden Version 1.0 of the Flood Damage Analysis package - HEC-FDA. Work is well along on expanding HEC-RAS for unsteady flow; the first release is planned for mid- FY 2000. An updated release of HEC-HMS is planned for FY 2000 that will include enhancements to the spatial precipitation and runoff modeling capability, continuous soil moisture accounting, and release of a snow melt adjunct software capability under development in cooperation with the Cold Regions Research and Engineering Laboratory. The HEC-FDA is undergoing improvement with a new release planned for FY 2000. New statistical uncertainty analysis, improved data-base operations, GIS capability, and a number of enhanced user features will be additions for the new release. Test Version 1.0 of a new reservoir operation program emphasizing real-time decision support was completed and is included in the suite of CWMS software mentioned in the above paragraph. Notable in late FY 1999 was release of the first of several GIS-based utilities for HEC software: HEC-GeoRAS (Arc/Info digital cross section extraction and flood inundation computation); to be followed in FY 2000 with an ArcView

version of HEC-GeoRAS, and HEC-GeoHMS (ArcView-based basin delineation and watershed parameters derivation and HMS model development).

Work supporting implementation of risk-based analysis for flood damage reduction studies continued at a steady pace this past year. In the previous seven years, twelve PROSPECT courses, sixteen on-site workshops and a number of executive and field project working sessions were held for a total of about 1,300 Corps professionals. PROSPECT courses will continue at about one per year/two years for the near term. HEC-FDA, the software package written to support this initiative, continues in widespread use by Corps offices. The Corps now routinely applies risk-based analysis for flood damage reduction studies. A National Academy of Sciences panel is near completion of a review of the Corps use of risk-based analysis. Their final report is due in mid- FY 2000. We began a research project to address hydrologic risk and uncertainty and environment restoration performance. This is an area of inquiry that is expected to grow. Another research project of importance is application of risk-based analysis to dam safety. A case example of determining the frequency and uncertainty associated with extremely rare floods is well along.

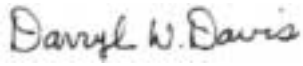
Six PROSPECT courses were conducted for a total of six weeks of training. The courses covered several hydrologic engineering and planning analysis topics. Attendance averaged about 25 students per course. Nine on-site workshops were also held totaling five weeks of sessions for 160 students. This continued the recent trend of reduced PROSPECT sign-ups and increased requests for on-site workshops. Topics presented included HEC-RAS, HEC-HMS, risk-based analysis, flood damage analysis, and reservoir operations/HEC-5.



Reimbursable project work was undertaken for 17 Corps field offices as well as HQUSACE, the Institute for Water Resources, Cold Regions Research and Engineering Laboratory, the Federal Emergency Management Agency, a combine of the State of California and Metropolitan Water District of Southern California, and the National Institute for Building Sciences. Projects include watershed and reservoir system modeling, water quality, risk-based analysis, river hydraulics, wetlands hydrology, water control management, regional statistical analysis, flood damage analysis, GIS applications in hydrology and hydraulics, and groundwater modeling. Our participation in the study to update flood frequency for the upper Mississippi continues, with major accomplishments in methodology development, and outreach to local publics. Also in the upper Mississippi, HEC is managing the project to make use of recent new digital map products to update the Mississippi Basin Modeling System. Two major water resource system analysis projects were completed this year: data compilation and simulation and optimization models for the Sacramento/San Joaquin rivers flood control systems; and data management and simulation and optimization models for the Panama Canal Expansion study. HEC was asked to continue the system model development for the next project phase of the Sacramento/San Joaquin watershed study, which began in late FY 1999. A significant project for HEC is the Tres Rios environmental restoration project. This project requires adaptation of HEC methods and tools to the important emerging mission area of environmental restoration/wetlands development. The total reimbursable project program was about $2.0 million with individual projects ranging from a few thousand dollars to near a million.

We expect the HEC program for FY 2000 will continue FY 1999 efforts at the increased pace reflected at the end of the year. We will continue fielding new versions of the

NexGen software packages HEC-RAS, HEC-HMS, and HEC-FDA, and companion GIS utility software. Also emerging will be another test version of the new reservoir simulation program, and initial unsteady flow capability of HEC-RAS (Version 3.0). Test Version 2.0 of the modernized CWMS will be installed and tested in four Corps offices. PROSPECT training will remain at about six courses and the number of field workshops will likely continue to modestly increase. Research and Development funding is expected to be level to modestly increase, software maintenance and support and CWMS modernization funding will remain at about FY 1999 levels, and reimbursable technical assistance and special projects will probably continue the recent upward trend. On balance, the result is expected to be a stable to slight increase in funding over that of 1999. The reorganization of HQUSACE, that will impact HEC, had not been announced at FY end. However, at press time, the reorganization was announced and we are now actively making management adjustments to implement the planned new structure. We do not expect the changes to adversely affect services to our customers.



DARRYL W. DAVIS
Director

Administration and Funds

Responsibilities

The Hydrologic Engineering Center was established in 1964 to provide applied research, training, and technical assistance in hydrologic engineering to Corps field offices. In 1971, responsibilities were expanded to include planning analysis. Current activities now address a wide range of hydrologic engineering and planning analysis concerns.

The annual program is based on: (1) program direction from the HQUSACE Civil Works Directorate (Planning Division and Hydraulics and Hydrology Branch, Engineering Division) and the Corps Research and Development Directorate; (2) requests for assistance from Corps district and division offices; (3) cooperative work with Corps research laboratories; and (4) cooperative work with other government and professional organizations. Program activities are coordinated on a continuing basis with HQUSACE proponents and the Corps' user community.

HEC is an element of the Water Resources Support Center headquartered in Alexandria, Virginia. The Water Resources Support Center provides Corps-wide water resources support services for the Directorate of Civil Works, Headquarters, US Army Corps of Engineers (HQUSACE). HEC has been granted authority, within the approved program, to deal directly with Corps offices and others.

Goals of the Hydrologic Engineering Center

The primary goal of HEC is to support the Corps in its water resources management responsibilities. This is accomplished by increasing the Corps technical capability in hydrologic engineering and water resources planning and management and providing leadership in improving the state-of-the-art in hydrologic engineering and water resources planning.

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By means of programs in research, training, and technical assistance, HEC maintains awareness of the problems and needs of the Corps and the nation. A commitment is also made to keep abreast of the latest developments throughout the profession, and to make use of this information in a manner best suited to the needs of the Corps.

HEC increases the effectiveness of the Corps and the profession by bridging the gap between the academic community, practicing hydrologic engineers, and planning professionals. Research and training activities that can be best accomplished by universities are not undertaken. HEC incorporates state-of-the-art procedures and techniques into manuals and comprehensive computer programs. The resulting products are made available to the Corps, and to other United States and international professionals through an effective technology transfer system of technical assistance, publications, video tapes, and training courses.

Research supplements relevant research at universities, private industry and other agencies. It develops systematic procedures that produce a quality product; it also saves

time for experienced specialists and enables less-experienced personnel to use procedures effectively.

Training develops the Corps workforce and reduces the time necessary for young engineers and planning professionals to become proficient in technical analysis. It also familiarizes more experienced professionals with new methods.

Technical assistance provides advice and assistance to Corps field personnel in the application of new or unfamiliar procedures to solve complex, precedent-setting water resources problems.

Administrative Services

Finance and accounting, contracting, supply, real estate, counsel, logistics and reproduction services are provided by reimbursable agreement with the Sacramento District (CESPK). Personnel support is provided by reimbursable agreement with the South Pacific Division (CESPD).

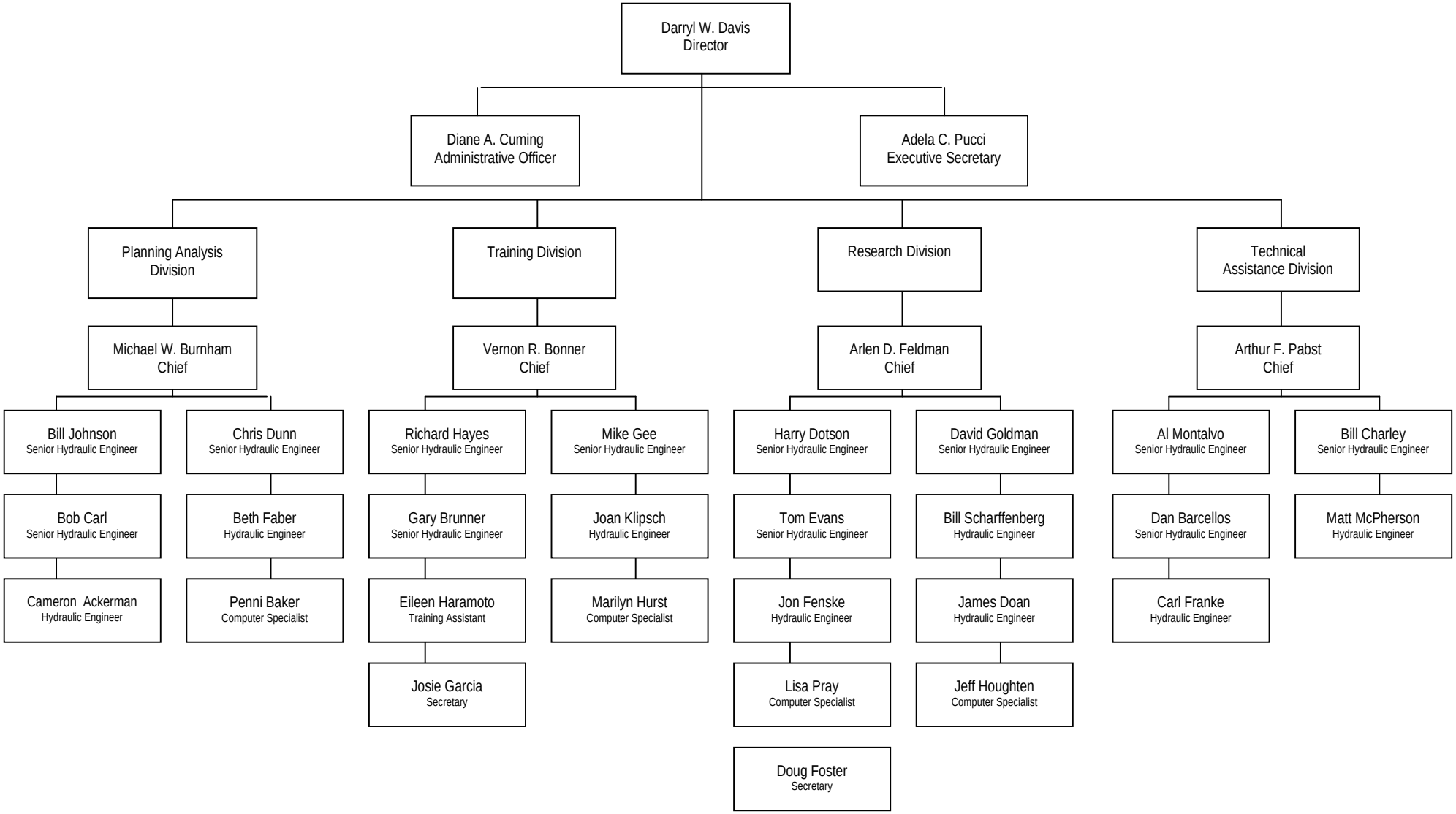
Facilities

The Center is located in Davis, California, near the University of California, Davis campus. Facilities include office space for the staff and visitors, a classroom with a capacity for 32 students, a library, a publications and video tape storage center, and computer equipment. The computer hardware consists of personal computers, several engineering workstations and a variety of supporting video, graphics and printing equipment.

Organization and Staff

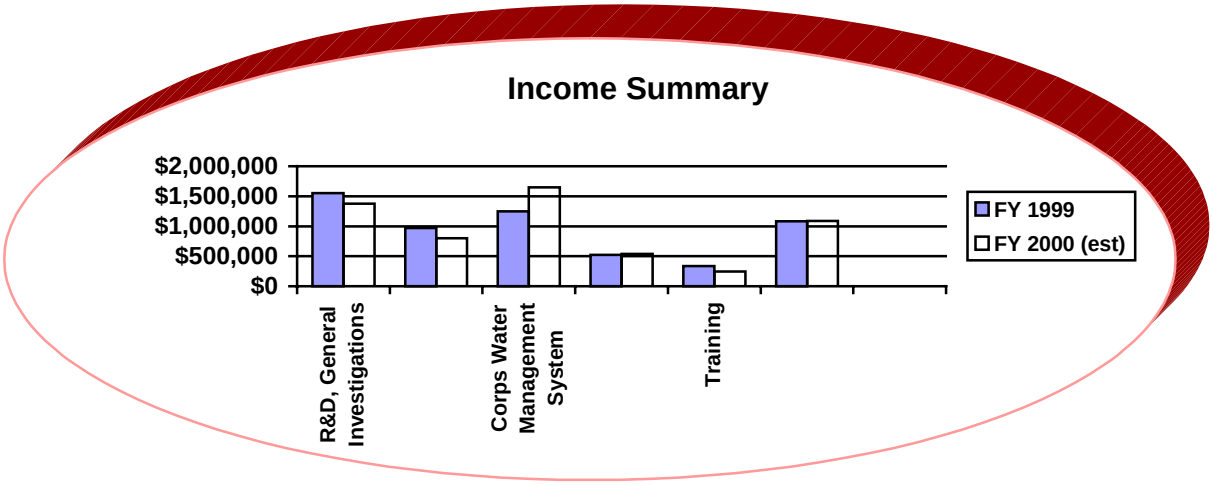
HEC is organized into five functional units as shown on the accompanying organization chart. HEC was authorized 41 full-time equivalent (FTE) positions during FY 1998 and for FY 1999. Those persons employed on permanent status are shown on the organization chart. HEC also employs temporary staff in engineering, computer science and clerical capacities.

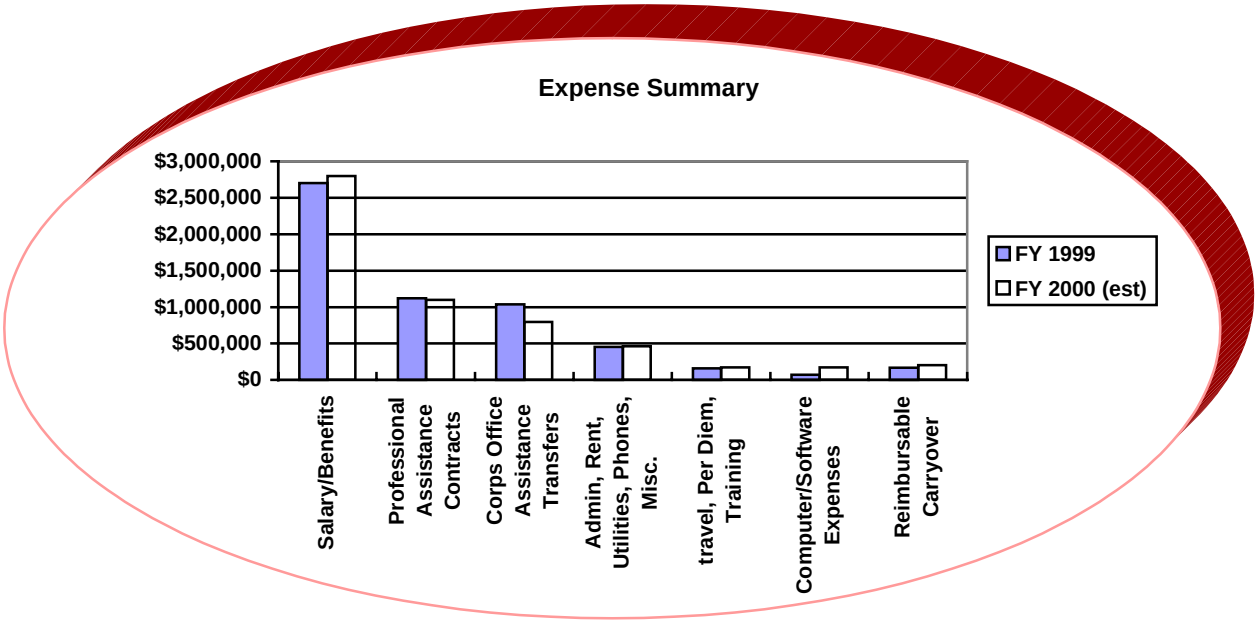
Hydrologic Engineering Center
Permanent Employees
As of March 2000



Funding

Funding is received from several sources: the Civil Works R&D program, special projects, the Corps-sponsored training program, field office subscriptions for computer software support, and reimbursable assistance. Reimbursable assistance includes work for Corps district and division offices; research and development laboratories; Institute for Water Resources; Planning Division, Civil Works Directorate, HQUSACE; Hydraulics and Hydrology Branch (H&H), Civil Works Directorate, HQUSACE; and other government agencies.





Research & Development

Corps field-office needs are the basis for HEC's research program. Corps headquarters and other Federal agencies also identify new research needs. Most of the research effort is technique-oriented and emphasizes a generalized solution to specific field problems. Research results are transferred to the field through training and technical assistance projects and through manuals, regulations, and computer software.

Planning, design, construction, and operation and maintenance of today's multiple-purpose water projects require complex interdisciplinary analyses. These complex problems present major methodological and computational tasks to water resources professionals. Research seeks solutions to these problems through development of systematic methods and the use of advanced analysis techniques.

Research Programs for FY 1999

Research was conducted in 17 work units as described in the following paragraphs. These work units represent specific technical needs identified in the Corps R&D program. HEC manages the Corps “Hydrologic Engineering” R&D Program and performs most of that work. HEC was also involved in the Corps research programs for "Risk Analysis of Water Resource Investments," "Geographic Information Systems," and “Risk Analysis for Dam Safety.”

Hydrologic Engineering Research Program

(In priority order)

- River Analysis System
- Catchment Analysis System
- Flood Damage Analysis Package
- Reservoir Analysis System
- Terrain-based H&H Modeling
- Statistical Methods in Hydrology
- Urban Hydrology Methods/Models
- Improved Streamflow Estimation and Project-Aquifer Impact Analysis
- Resolving Water Allocation and Use Conflicts
- Comprehensive Watershed Studies - Internet Resources
- Development of an Initial Data Warehouse for Coralville Reservoir

New Work Units for FY2000

- 1D Unsteady Modeling for River Analysis
- Integration of HEC NexGen Software for Watershed Studies
- Flood Hydrology and Hydraulics of Wetlands

Risk Analysis of Water Resources Investments

- Risk-based Analysis for Flood Damage Reduction Studies Computer Program
- Risk & Uncertainty of Hydrologic Engineering Analysis for Riverine Environmental Restoration Studies

New Work Unit for FY2000

K Residual Risk of Flood Damage Reduction Projects

Geospatial Information Systems

K Flood Damage Analysis Using GIS Technology

Risk Analysis for Dam Safety

K Planning Hydrologic-and-Hydraulic-Dam-Safety Risk Analysis
K Assessing Hydrologic Loading Uncertainty
K Estimating Probability of Extreme Floods

Hydrologic Engineering Research Program

The main focus of this research program, since October 1990, has been the development of the next generation (NexGen) of hydrologic engineering software. The NexGen program packages are planned as successors to the widely used existing HEC programs. The software includes many new and updated engineering algorithms and is designed for the interactive, desktop computer environment with graphic user interfaces. Much emphasis has been placed on the engineer-computer interface to enhance the computational power for engineering analyses. The software has a common, distinctive look and feel, uses common software libraries where possible, and is modular among user interface, graphical and database support, and analytical components. The NexGen work is progressing very well; several versions of the river hydraulics, watershed hydrology, and flood damage systems have been released, and the reservoir system simulation work became active.

River Analysis System

This work will produce a consistent set of one-dimensional river analysis software tools for use by H&H engineers in workstation and PC environments. A single geometric representation of the river and floodplain will be used for all simulations; sediment scour, transport, and deposition capabilities will also be included. During FY 1995, the River Analysis System (HEC-RAS), Version 1.0 program was completed, the Hydraulic Reference and User's manuals were published, and the package started distribution in August 1995. The program is a Windows-based standard-step model that computes steady-flow profiles for subcritical, supercritical, or mixed flow regimes. During FY 1996, Versions 1.1 and 1.2 were released to provide error corrections and added program features. Version 2.0 was released in FY 1997 and included several improvements for flow through bridges and graphical editing of cross sections. FY1998 (latest - Version 2.2). New features include floating debris on bridge piers; new bridge design editor; graphical cross-section editor; and several new output variables. Much improved bridge and culvert hydraulics were included.

Accomplishments and Outlook . . . . The final steady-flow features for split flow optimization and bridge skew were completed in FY1999. An initial test version of the unsteady flow module in HEC-RAS was developed. It provides the basic computational elements for the unsteady flow program, but not all the hydraulic structures features of the full UNET program. In FY2000, the final steady-flow HEC-RAS capability, Version 3.0, will be released including updated manuals. That will conclude this work unit and another new work unit for 1D Unsteady Modeling for River Analysis will begin.

Catchment Analysis System

This work unit is developing methodologies and numerical models for both continuous and event-oriented simulation of complex flood and low-flow river basin hydrologic processes for the NexGen Hydrologic Modeling System (HEC-HMS). The simulation capabilities developed here will be applicable to planning, design, and real-time water control. The analysis system will be built of modular components with a catchment model as the central component. The modular, object-oriented design will facilitate inclusion of special methods for interaction with river hydraulics, interior area flood analysis, urban runoff, groundwater connections, GIS, etc. A graphic user interface, GUI, was developed to maximize the engineer's ability to prepare, understand, and display data and results.

Accomplishments and Outlook . . . . HEC-HMS Version 1.0 was released in FY 1998. Snowmelt simulation capabilities were initially added in a stand-alone program under a contract with CECRL. Capabilities for continuous simulation were added to HEC-HMS computational engines and the graphic user interface programming was begun. A draft Technical Reference Manual was completed. Several improvements were made to the Interior Flood Hydrology program. In FY1999, an updated version, 1.1, was released, and version 2.0 with continuous soil moisture accounting simulation capabilities and a complementary, separate, snow simulation program were Beta tested. The Technical Reference Manual and User's Manual were also updated. In FY2000, Version 2.0 of HEC-HMS will be released and new capabilities for dam safety and project planning capabilities will be tested.

Flood Damage Analysis Package

This work unit is developing a next generation of analysis methods and software for flood damage computations. The goal is to enhance the Corps' capability to develop structure inventory information, and to estimate the effects of various project works on flood damage reduction. The next generation Flood Damage Analysis (HEC-FDA) computer program replaces the old FDA package that included the Structure Inventory of Damage (HEC-SID), and Expected Annual Damage (HEC-EAD) programs.

Accomplishments and Outlook . . . . Extensive testing and upgrading of the provisional version of HEC-FDA were performed and Version 1.0 was released in FY 1998. The user's manual was also significantly upgraded. Several enhancements were made to the flood damage computation routines, output reports, and user interface. This work was closely integrated with the Statistical Methods in Hydrology work unit and another work unit in the Risk Analysis R&D Program to ensure appropriate new risk and uncertainty methods were developed and incorporated. In FY1999, an Applications Manual was drafted and the HEC-FDA software was updated. In FY2000, technical capabilities will be expanded, design and coding for incorporating a front-end user interface consistent with NexGen HEC-HMS, HEC-RAS, and GIS capabilities will be developed and released as Version 2.0.

Reservoir Analysis System

This work unit is developing a family of reservoir analysis tools to facilitate investigations ranging from reconnaissance-level planning studies to detailed reservoir regulation plan investigations. The family of programs will include the existing HEC-5 for multi-purpose simulation, a reservoir optimization capability, a systems analysis-based reservoir system evaluation methodology for large-scale screening studies, and modular reservoir

regulation routines. These reservoir regulation routines can be implemented in real-time analysis for complex flood and low-flow conditions. Field needs were surveyed and major requirements defined. The Prescriptive Reservoir Model (HEC-PRM) was designed, developed, tested, and released; it is a systems analysis model for evaluation/screening of multi-purpose, multi-reservoir systems. In FY97, a multipurpose reservoir model graphic user interface was developed.

Accomplishments and Outlook . . . . In FY 1998, a new operation algorithm was developed and incorporated in a prototype reservoir model. The basic reservoir GUI developed last year was restructured to incorporate the new algorithm. In FY1999, the beta HEC-RSS reservoir model and a draft user's guide were developed to meet Version 1 water control requirements. That beta test provided input for corrections and expanded capabilities. In FY2000, Version 1.0 of HEC-RSS and User's Manual will be released and preparation of Version 2.0 will begin.

Terrain-based H&H Modeling

Existing hydrologic and hydraulics models do not adequately represent the spatial variation in meteorological processes and geographic characteristics. This work unit will develop spatially distributed hydrologic and hydraulic modeling capabilities that can use the remote sensing and GIS data effectively. Digital elevation data will be the primary source of topographic information with which to develop spatially distributed models. Spatial precipitation will be based on both gaged data and radar sensed distributions. These spatial data representations will be used in HEC's next generation H&H modeling projects.

Accomplishments and Outlook . . . . A digital terrain modeling capability was developed to support HEC hydrologic models. It identifies and delineates watersheds and rivers, creates the structure for HEC-HMS and georeferences a standard hydrologic grid to the National Weather Service's (NWS) radar rainfall grid. The hydrologic model uses the spatially distributed rainfall and watershed information to compute runoff. The following tasks were completed: 1) proposed Standard Hydrologic Grid (SHG) has been adopted and programs to support it, including resampling of precipitation data from the NWS Hydrologic Rainfall Analysis Program (HRAP) grid; 2) A method for interpolating gaged precipitation data to a grid (HRAP or SHG); 3) A GIS program for producing NRCS curve numbers from this data in conjunction with land use coverages, 4) Methods for transferring terrain descriptions from GIS sources to HEC-RAS and HEC-HMS ; and 5) GIS methods for Green and Ampt infiltration were developed and tested. In FY1999, a GIS preprocessor for HMS, GeoHMS was designed and built via a Cooperative Research and Development Agreement with the Environmental Systems Research Institute, Redlands, California. An ArcInfo version of GeoRAS was released. In FY2000, ArcView extensions for GeoHMS and GeoRAS will be released.

Statistical Methods in Hydrology

The objective is to develop a package of hydrologic statistics tools and documentation for use by field offices. These tools will be in the language of the hydrologic engineering profession without the highly statistical and mathematical jargon used by the developers of the theory in other sciences. Flow frequency at multiple stations, stochastic methods, regression techniques, etc., are to be included in this package. Statistical methods for both flood and low-flow hydrology will be developed. These methods will include probability assessments for generated flow sequences. A general design for the Corps hydrologic statistics package has been scoped out and algorithms developed for missing

data fill-in. The Beta Version 1.0 of STATS was released in FY 1997. Methods for improving regional estimates of skew were investigated and presented to the Corps' Hydrology Committee and the Interagency Bulletin 17B work group.

Accomplishments and Outlook . . . . In FY 1998, the new missing data fill-in algorithm was completed. Design of generalized statistical methods capabilities for HEC-DSS was undertaken. Regional flow frequency estimation methods were documented. FY 1999 work focused on new flood frequency analysis procedures relative to the use of historic floods. The expected moment algorithm was compared with the Bulletin 17B conditional probability adjustment weighting procedure for historic floods. Former Bulletin 17B work group members reviewed the results. That completes current plans for this work unit; new work units will be developed as the need arises.

Urban Hydrology Methods/Models

Methodologies and software algorithms will be developed for the specialized nature of urban hydrology and hydraulic studies. Existing tools in the profession will be used and/or adapted to meet Corps needs. Interconnection of modeling capabilities (e.g. HEC-HMS and UNET with EPA-SWMM) will be facilitated by implementing access to the HEC Data Storage System, HEC-DSS. Guidance and software will be provided for routing of flows through culverts, pipes, and the many man-made features of urban areas.

Accomplishments and Outlook . . . . A state-of-the-practice seminar was held to describe Corps capabilities and needs to leaders in the profession in FY1994. The seminar proceedings (published in FY1995) identified and summarized Corps needs and directions for improving urban hydrologic and hydraulic methods. The two primary needs were better interfaces between hydrologic and hydraulic models, and improved hydraulic simulation of storm sewer networks. In FY1995 and 1996, the UNET model was tested on storm sewer networks. In FY1997, software and guidance was provided to EPA-SWMM model developers for incorporation of HEC-DSS linkages for input and output. In FY1998, kinematic wave routing for steep channels was added in HEC-HMS. In FY1999, improved urban hydrologic and hydraulic features were tested for HEC-HMS and HEC-RAS. User guidance for analyzing different urban hydrologic and hydraulic flow situations was drafted. In FY2000, training documents for application of HEC-HMS in urban areas will be completed along with any additional software updates. These new modeling techniques will be incorporated in the HEC-HMS, and HEC-RAS.

Improved Streamflow Estimation and Project-Aquifer Impact Analysis

This work will develop, document, and deploy a suite of analysis methods and computer routines to enable computation of the rate and volume of water exchange between the ground and the surface. The computations will be designed to make use of readily available information and be tailored to the needs for planning, design and operation of existing and potential Corps' projects. The computations will include analysis of rivers, lakes, reservoirs, aquifers, wells, diversions, and other inflow/outflow sources. Computer programs will be developed using state-of-the-art software engineering methods.

Accomplishments and Outlook . . . . Corps groundwater needs and capabilities of the profession have been assessed through field survey, literature review, review of field

projects, and participation on the Army Groundwater Modeling committee. Conceptual designs for connection of surface/groundwater models have been made. A surface reservoir package was developed for the USGS MODFLOW model; it was published as USGS Open File Report 96-364. A drawdown algorithm was developed for calculation of water levels in wells simulated by MODFLOW. A review of available continuous SW/GW models in profession was completed. In FY1999, algorithms for simulating the interaction of surface water flows from HMS with groundwater flows from MODFLOW were analyzed. The first stages of a field application of HMS-MODFLOW, including streamflow measurements and data gathering on the Humboldt River in Nevada, were initiated. In FY2000, this work will be suspended because of budget cuts.

Resolving Water Allocation and Use Conflicts

The original objectives were to develop generalized water allocation, conflict resolution capabilities; these were modified based on the response of the field review group. Emphasis is now on analytical methods to assist in Corps studies for reservoir operations where conflicts exist. A framework for resolving water allocation and use conflicts using non-economic relative-cost penalties will continue to be developed, applied, and refined. Systems analysis techniques (linear programming and network analysis) and traditional simulation models will provide a means for identifying, understanding, and resolving conflicts. The HEC Prescriptive Reservoir Model (HEC-PRM) and Linear Programming for Flood Control Operations (FCLP) programs are key components under this work unit.

Accomplishments and Outlook . . . . In FY1996, improvements were made to HEC-PRM, and a seminar titled "Resolving Water Allocation and Use Conflicts" was held. The Flood Control Linear Program (HEC-FCLP) was developed to model reservoir flood control operations at a range of time intervals. HEC-PRM was tested for conflict resolution applicability in conjunction with other projects on the Bill Williams River and the South Florida Everglades; and HEC-FCLP was similarly tested on another project for the Iowa and Des Moines Rivers system. In FY1998, enhancements were made to HEC-FCLP to allow better representation of flood damage costs and the efficient solution of very large linear programs. In FY1999, field testing of the Beta version of Corps Flood Control Linear Program (HEC-FCLP) was performed and a draft user's manual prepared. In FY2000 conflict resolution information will also be developed via post processing of HEC-RES simulation results. Also, HEC-FCLP, -PRM, and -RES will be updated and enhanced for conflict resolution applications.

Comprehensive Watershed Studies - Internet Resources

There are three principal needs addressed by this work unit: (1) the need to increase the ability of Corps offices to quickly and effectively access a broad range of hydrologic/hydraulic and system analysis data information to help in describing a watershed economically, ecologically, socially, and culturally; (2) the need to improve the information base that tells the story of what the management of Corps projects produces in flood damage reduction, navigation, hydroelectric power generation, recreation, fish and wildlife enhancement, water quality, and other project purposes both within and outside the watershed; and (3) the need to develop guidelines for the effective utilization of this information in watershed planning. Literature review was performed and discussions with several Corps offices on watershed studies conducted. Funding

reductions significantly limited the start and effort of this work. Because of those constraints emphasis is now on the use of the Internet.

Accomplishments and Outlook . . . . In FY 1997, initial efforts were undertaken to explore the role of the Internet in comprehensive studies. In FY 1998, a framework describing the potential of the Internet in watershed studies was proposed. Web site development ideas and concepts were employed on a field project. In FY1999, a test application of the framework was made. That completes the current plans for this work unit.

Development of an Initial Data Warehouse for Coralville Reservoir

Congress directed the Assistant Secretary of the Army (Civil Works) to support the comprehensive Flood Impact Response Modeling System (CFIRMS) through research proposed at the University of Iowa. Initial work is developing a data warehousing system and structure to enable high-speed access to both static and dynamic data sets that might ultimately involve such diverse data streams as digital terrain data, soils, geology, soil moisture, runoff, rainfall, land values, reservoir and channel water levels, flood routing, crop values, urban landscape mapping, archaeological data bases, and critical facilities and capacities. The issues of data registry, dynamic data input and retrieval, security, high-speed access to on-line data, and data sharing protocols (both operational and administrative) must first be addressed. An integrated solution for this data warehouse at the Corps Coralville reservoir was completed.

Accomplishments and Outlook . . . . The initial data warehouse and data input connection's infrastructure was expanded. The data warehouse was tested on selected data sets; installation at the Rock Island District was temporarily made via computer linkage to the University of Iowa system. This work unit was completed in FY1999 with the addition of more data and improved access to the data warehouse for the Rock Island District.

New Work Units for FY2000

- 1D Unsteady Modeling for River Analysis
- Integration of HEC NexGen Software for Watershed Studies
- Flood Hydrology and Hydraulics of Wetlands

1D Unsteady Modeling for River Analysis

A comprehensive unsteady-flow analysis methodology will be developed in the River Analysis System, HEC-RAS. The package will be designed and developed to meet one-dimensional steady state and unsteady-flow river hydraulic analysis needs for floods and low flows. Sediment scour, transport, and deposition capabilities will also be developed in the future. This river analysis capability will be encompassed in a single geometric representation of the river and floodplain. In FY2000, new features will be added to develop the initial HEC-RAS unsteady-flow capability. An updated version (3.0) will be released during FY2000.

Integration of HEC NexGen Software for Watershed Studies

This work unit will create procedures and capabilities to provide a fully integrated suite of HEC models for watershed and water resources management studies. The integration will make extensive use of the modernized Corps Water Management System (CWMS) to develop software links for data processing, modeling and spatially referenced displays. A watershed style Control and Visualization Interface (CAVI), tailored from the CWMS CAVI, will be designed as the umbrella interface integrating the suite of HEC models. To ensure district shared-data capability, the watershed CAVI will also link to CWMS: database of watershed physical data, precipitation, streamflow, and model parameters; spatially referenced data maps and displays; and internet/web-sight links. The terminology, analysis procedures, and output will be consistent with requirements of ER 1105-2-100, ER 1105-2-101, EM 1110-2-1619, and other Corps guidance criteria. The final product will streamline the analytical process, while producing more consistent results, and shared displays.

Flood Hydrology and Hydraulics of Wetlands

This work unit will characterize the hydrologic and hydraulic impacts of wetlands on individual areas and on regional floods. Analytical methods for determining the hydrologic and hydraulic impacts of wetlands (or loss thereof) on a regional basis will be developed, tested, and documented. The research will begin with: a review of pertinent literature; identification of completed and ongoing Corps wetlands delineation and impact studies; gathering of hydrologic, geographic and other information on available studies; and formulation and testing of indicators and methods for analysis of wetlands impacts. After establishing methods for analyzing individual areas, methods for regional wetlands impacts analysis on floods will be developed and tested. This work will be closely coordinated with the work unit on "Integration of HEC NexGen Software for Watershed Studies."

Risk Analysis of Water Resources Investments Research Program

Risk-based Analysis for Flood Damage Reduction Studies Computer Program

The Corps Institute for Water Resources (IWR) manages this research program. The objective of HEC's work unit is to develop, document, test, and deploy risk-based analysis flood damage computation software and applications methodology for Corps-wide use. The analysis requires that the statistical uncertainty in variables such as flood frequency, flood stage, and flood damage be quantified and included in the analysis. The work is closely coordinated with IWR (economics), WES (hydraulics), and Corps HQUSACE Planning and Engineering Divisions. Extensive technology transfer is accomplished through workshops, new training courses, and guidance documents. The provisional version of the NexGen HEC-FDA program was completed and distributed to Corps field offices in FY 1997. The program is consistent with the risk-based analysis requirements of ER 1105-2-101, and procedures and output defined in EM 1105-2-1619.

Accomplishments and Outlook . . . . The initial public release Version 1.0 of the NexGen HEC-FDA computer program was made in FY 1998. Enhancements to the provisional version included additional accommodating uncertainty functions, new output reports, and better geotechnical assessments for levees/flood walls consistent with

engineering and planning technical requirements. In FY 1999, project costs with uncertainty and a new front-end interface was added to the program, and Version 2.0 software and documentation were prepared for release. This work unit is now complete.

Risk & Uncertainty of Hydrologic Engineering Analysis of Riverine Environmental Restoration Studies

This was a new work unit in FY1999. The Corps studies and implements riverine environmental restoration projects to protect and enhance the nation's environment. Notable examples include the Upper Mississippi and Kissimmee Rivers restoration projects. Federal policy is that risk-based (risk and uncertainty) analyses be incorporated into the technical studies performed by water resources agencies. Riverine environmental restoration studies require the statistical uncertainty of key variables associated with low- and high-flow regimes affecting the design, maintenance, and operation of the project over its life be quantified and included in the analyses. Low-flow uncertainty variables may include long-term records, droughts and their persistence, water levels and depths, duration's, and seasonal variations. High flows are of interest primarily to assess maintenance requirements and cost and any induced flooding impacts. ER 1105-101 and EM 1110-2-1619 cover the uncertainty analysis requirements for high-flow analysis considerations.

Accomplishments and Outlook . . . . In FY1999, accomplishments included development of a basic hydrologic analysis framework; definition of hydrologic parameters important in restoration studies; examination of risk and uncertainty associated with these parameters; and initiation of field contact on hydrologic analysis being conducted in Corps restoration studies.

New Work Unit for FY2000

Residual Risk of Flood Damage Reduction Projects

Flood damage reduction studies involve an integrated and complex analysis process designed to provide decision-makers with an array of information on viable alternatives. This process presently lacks sufficient procedures for explicitly defining the residual flood risk associated with various project types and site conditions when the designed operation is significantly impaired or the project capacity is exceeded. This work unit will create procedures and capabilities to define and communicate the residual flood risk for without-project conditions and with various project types and study settings. This will include: information on the flood characteristics resulting from impaired-operation for a range of events; development of project performance risk indicators and information; and assessment of capacity exceedance events impacts on the physical study setting, general population, and the responsible response agencies. The methods must be performed within existing Corps engineering requirements and include such components as risk-based analysis approaches.

Geospatial Research Program

Flood Damage Analysis Using GIS Technology

Planning flood damage reduction projects requires an integrated participatory approach, the use of a variety of information and data sources, and analysis procedures and results that are easily interpreted by the participants and decision-makers. The variety of data and analyses required can easily bring about: duplication of efforts; increased field survey time and costs; complicated spatially distributed displays of results; and loss of information useful to other and future projects. GIS data capabilities together with an analytical software framework can provide flood damage analyses, and results displays to meet the needs of these complex flood damage reduction studies. Algorithms will be developed and integrated with the HEC-FDA computer program. The work will be coordinated with other Corps GIS activities such as those being developed under the Corps Water Management System by CECRL, and other HEC R&D work.

Accomplishments and Outlook . . . . In FY1998, this work unit began with detailed design of approaches for interfacing HEC-FDA with GIS capabilities. The design entailed an inter-relational query between a digital terrain model, a digital water surface and a grid-cell or structure inventory. The design allows for aggregation of damages, defined by grids or individual structures, to an index location for predefined floods (stages). In FY1999, prototype grid-cell flood damage analysis methods and displays were completed. Algorithms for the beta grid-cell software were developed. A prototype of the GIS/image structure inventory analysis capabilities and HEC-FDA interfaces were also developed. In FY2000, the initial version of HEC-FDA with grid-cell GIS capabilities will be released.

Risk Analysis for Dam Safety Research Program

Planning Hydrologic-and-Hydraulic Dam-Safety Risk

The purpose of this work unit was to plan the R&D for H&H aspects of the Risk Analysis for Dam Safety Research Program. The Hydrologic Engineering Center, HEC, and the Coastal and Hydraulics Lab, WES-CHL, reviewed recent dam-safety risk-analysis work in the profession. Those ideas were discussed with Corps management and field offices in R&D planning meetings. R&D work units were formulated from the information; the following work units are HEC's part of this research program. This work unit is complete.

Assessing Hydrologic Loading Uncertainty

This work will focus on quantifying uncertainty in the estimates of hydrologic variables to obtain the uncertainty in the estimates of extreme floods. Hydrologic variable candidates are extreme precipitation, watershed infiltration/interception, antecedent flood/moisture conditions, river routing, and antecedent reservoir levels. Event trees, numerical integration (Monte Carlo simulation) and other approaches in the risk analysis profession will be used to derive the uncertainty in the extreme flood estimates given the likely estimates of the hydrologic variables. Methodologies, software, and guidance will be developed for use by Corps field offices.

Accomplishments and Outlook . . . . In FY 1999, methods for estimating uncertainty in precipitation and floods were reviewed and a position paper drafted. A promising

method for analysis and extrapolation of rainfall statistics and combination with runoff factors in a Monte Carlo simulation was identified. A contract was let (in conjunction with the next work unit) to perform a test application of this methodology on a case study; work began with analysis of precipitation statistics on the American River watershed near Sacramento, California. In FY 2000, the case study evaluation of this approach will be completed. Recommendations for a Corps-wide approach and software will be made.

Estimating Probability of Extreme Floods

The extreme-flood probability analysis will focus on approaches recommended by the National Research Council and recent national and international efforts. In particular, recent work with respect to estimating the probability of extreme precipitation, paleoflood magnitudes, and impacts of climate change will be evaluated. Methods will be developed to extrapolate flood probabilities of historical floods to rare floods and extreme probable maximum events. The applicability of the methods in different geographic areas will also be evaluated, e.g., paleoflood evidence is not as prevalent in the eastern U.S. Methodologies, software, and guidance will be developed for use by Corps' field offices.

Accomplishments and Outlook . . . . In FY 1999, a review of the state-of-the-art of methods for estimating the probability of extreme floods was made. The efforts concentrated on paleoflood methodologies and extreme precipitation estimation. A promising methodology for estimating and extrapolating extreme precipitation and computing runoff with a Monte Carlo simulation was identified and a contract let (in conjunction with the above work unit) for a case study evaluation. Methods for paleoflood magnitude and frequency estimation were reviewed and a summary report written. Potential methods for use of paleoflood information in flood frequency analysis are being investigated via participation in a professional society committee for that purpose. In FY2000, the paleoflood information paper will be published and the feasibility of estimating the probability of extreme floods will be assessed. Recommendations for a Corps-wide approach and software will be made.

Corps Water Management System

The Corps Water Management System (CWMS) provides improved Automated Information System (AIS) support to enable the Corps to efficiently and effectively accomplish the water control management component of its Civil Works mission. This includes water management of the more than 600 dams and reservoir projects constructed by the Corps. The CWMS will:

a) acquire project status and hydromet data in real-time;
b) store, manage, and report hydromet and project data, documents, imagery, and other data;
c) model, forecast, and simulate reservoir and river status; and
d) perform decision support analysis and information dissemination.

The CWMS project includes replacement of pre-1990 computer and related hardware; upgrades to field instrumentation and communications equipment; and upgrades of existing Water Control Data System (WCDS) software, including porting existing products, modifying and upgrading existing products, and development of new software products. HEC is responsible for development of new Corps-wide software for the CWMS. Subsequent sections describe the associated software activities. Major efforts have been completed that include development of system requirements, and the conceptual design of system components. Current efforts are focused on development and implementation of CWMS Test Version 2.0 at each of four field test sites.

The CWMS project is making extensive use of products developed under the Hydrologic Engineering R&D program. In several instances, noted in the following descriptive information, joint R&D and CWMS funding is supporting product development and integration into CWMS.

Data Capture

This CWMS component task provides water control sites connectivity to required data sources. Candidate sites include; NWS-AWIPS (NEXRAD products), NWS-AFOS, GOES/DOMSAT, land based radio, ALERT receive sites, and cooperating agency networks.

Accomplishments and Outlook . . . . CWMS software has been implemented at each of the four field test sites. Testing is under way to stress these components over wide area network conditions. Data capture components utilize network socket connections, which provide great flexibility for acquiring and distributing base water data information. At the Baltimore field test installation, identical data feeds that are processed locally in Baltimore are also received across the CEAP network in Davis, California for processing. These data processing tests are run on a 24 hours per day, 7 days per week basis. It is essential that access to critical operational data be highly reliable and available via alternate sources.

Future activities include continuous ongoing testing of the software. A feature to be implemented in FY 2000 is the capability of the data acquisition components to report the status of the flow of information and of the components themselves. If a failure in the

data feed being processed is found, the CWMS message system will raise an alarm condition so that the problem can be diagnosed and corrected. By active monitoring of the system the manager will be informed in a few minutes of detection of the problem, rather than having to wait until it is discovered.

Data Decoding, Transformation, and Validation

Current data streams being processed are for GOES and SHEF encoded products. The tasks involved are decoding software and graphical user interface for the creation of decoding criteria associated with SHEF and GOES data. Conversion of incoming data will be completed. Multi-level screening and validation of raw data will also be completed.

Accomplishments and Outlook . . . . Field Test Version 1.0 of the CWMS data capture, decoding, transformation and validation is functional and being tested at each of the four field test sites. A graphical user interface for the SHEFIT decoding criteria is available to aid data preparation. Implementation of the transformation and validation components of the CWMS work is currently based on existing WCDS capabilities. These procedures reprocess a full set of data in time and space, regardless of the actual data received. In FY 2000, testing will continue and data transformation and validation will be extended to operate only on data received in a preceding time period.

Data Base System

Development of data base technology will supply information of a wide variety, such as: hydrologic data, meteorological data, water quality data, project descriptions and design parameters, manuals, reports, project documents, geographic information, spatial data displays, maps, satellite images, and ultimately sound and video. This will provide the means and standards to have a common nomenclature and structure to data bases located in all Corps of Engineers CWMS computer systems.

Accomplishments and Outlook . . . . Within the context of a CWMS Test Version 1.0 Software System, a Data Base Interface (DBI) application was designed, developed, and demonstrated. Other CWMS components access and store data by passing data objects to the DBI for storage and retrieval from the Oracle relational data base management system (RDBMS). An application with a graphical user interface was also designed, developed, and implemented to define and edit location and time series identity and definition information. This application makes use of the CWMS messaging, the DBI, and the Oracle RDBMS and provides a verification of overall functionality. The software developed in this application is reusable in other CWMS applications wherever there is need to define or edit locations or time series.

The Field Test Version 1.0 data base subsystem (DBI and Oracle) are being used in the four field test sites to manage time-series data and location information as they appropriately move between CWMS applications and the CWMS Oracle data base as specified for Version 1.0 requirements. In FY 2000, Test Version 2.0 is being developed to run within a separate instance of the Oracle data base. This allows ongoing testing of Test Version 1.0 in parallel with development and test of Test Version 2.0. The parallel execution of multiple instances of Oracle is a requirement for installation of new software releases in the actual field production environment.

Application/Data Base Interface, Data Reporting and Dissemination

A system for retrieval and dissemination of water control data within the office, the Corps, and the general public is being tested. The system includes retrieval software which will access and display data from the water control database. The system relies on current Internet Web server and browser technology for easy access and display of the information from the database. Script processes on the water control server provide the mechanics to display the text and graphics. Procedures for automatic updates and ad-hoc requests also exist. Separate internal Corps only and external public Web servers are supported. The Corps only internal system is designed to meet the needs of in-house Corps water management decision makers, provide special access for Corps functions such as Public Affairs and Emergency Operations for display of sensitive information not accessible to the general public.

Accomplishments and Outlook . . . . The major accomplishment for FY1999 was the implementation of sample product generation capabilities. Web pages depicting "Current Conditions," "Model Results," and "Inundated Area" were used as examples of this capability. The Web pages are generated dynamically in the CWMS software from user requests or clock events. Script processes are invoked which read the data from the database, generate the Web pages, and then post the pages to the Web server.

With direct support from the Baltimore District sample products are being tested that directly access the Oracle data base for their update information. Future work in FY 2000 includes the development and enhancement of the Data Dissemination user interface which will allow a more general control of the Data Dissemination process.

In FY 2000, the implementation of public Web servers will include provisions for moving data and ad-hoc Web server requests from public machines outside of the firewall to processing machines inside the firewalls.

Data Archiving

This task provides an archiving system for CWMS data and files. Archive of regularly generated daily log files is being tested on each of the four field test sites. Oracle database archive files will be organized to provide logical groupings of related data. Operational data from automated data acquisition will be organized to archive both "raw" and processed information. Large data sets will be partitioned into logical groupings by geographic region, calendar year, and/or data category. Automated means will be provided for periodic archiving and as needed purging of information from the CWMS data base. Means will also be provided for automated retrieval from the data archive and placement into the CWMS data base or standard dissemination files.

Accomplishments and Outlook . . . . Testing of the daily log file archiving is continuous. In FY 2000, this capability will be extended to include the archive of files generated during model execution. The procedures to create Oracle archive and backup files will be defined and tested.

Flow Forecasting, Forecast Evaluation

Hydrologic forecast models are designed for effective and efficient runoff forecasting for a broad range of storm-runoff and low-flow conditions. The structure of the forecast model allows for incorporation of spatially distributed inputs (spatial precipitation) and parameters. The input and data-handling structures of models enable convenient specification and centralized interfaces to the model data base. The model will permit parameter-state updating based on real-time feedback. In addition, the model is be coupled with hydraulic, reservoir system, and damage analysis models. The forecast software utilizes components of the Hydrologic Modeling System (HEC-HMS), which is being developed under the Catchment Analysis System work unit of the Hydrologic Engineering R&D program.

Accomplishments and Outlook . . . . Capability to use distributed (cell-specific) SCS Curve numbers with the ModClark method is incorporated in HEC-HMS. Capability to store basin states (values of state variables) associated with losses, runoff transformation, baseflow and routing is also incorporated in HEC-HMS. In FY 2000 work efforts will include development of practical continuous moisture accounting capabilities. The capability to save/view/edit basin states, and to “hot-start” a simulation from saved basin states was implemented. The Meteorological Forecast Processor (MFP) which enables formulation of future-precipitation scenarios for use in forecasting is under test. The preprocessor Hydrologic Forecast Processor (HFP) which enables adjusting runoff parameters for forecast-specific application of HEC-HMS is also being tested. Work will continue on implementation of snow simulation.

Also in FY 2000, algorithms will be developed to provide parameter adjustments based on observed system conditions.

Reservoir System Simulation

The purpose of this work is to incorporate a family of reservoir tools into the CWMS. This capability is intended to meet the needs of water managers to make reservoir release decisions for complex systems of multi-purpose reservoirs. The reservoir analysis tools for flood and complex low-flow conditions are to be developed under the Hydrologic Engineering R&D program, Reservoir Analysis System Work Unit.

Accomplishments and Outlook . . . . During FY 1999, the Test Version 1.0 RSS provided a simple capability that allows a reservoir to operate for itself. FY 2000 activities include extending the operation criteria to allow a reservoir to operate for any number of downstream conditions as well as itself. The next level of operations will include multiple reservoirs operating in a system.

River Hydraulics, Stage Forecasting

The modeling of river hydraulics for stage forecasting includes both steady state and unsteady hydrodynamic modeling. A Hydrologic Engineering R&D work unit is developing the River Analysis System (HEC-RAS) computer program to provide steady, unsteady and sediment transport functions. The objective of this task is to incorporate HEC-RAS within the water control system to provide steady and unsteady flow modeling.

Accomplishments and Outlook . . . . Field test Version 1.0 is under test in each of the four field test sites. These tests utilize the steady state capabilities of the HEC-RAS program. The GUI that is available for the CAVI allows specific model parameters to be varied for evaluation alternative hydraulic conditions. In FY 2000 unsteady flow HEC-RAS capabilities will be integrated into the CWMS system.

Flood Impact Analysis

The HEC Flood Impact Analysis (HEC-FIA) computer program is designed to be fully integrated with the CWMS with capabilities to: 1) provide ready assessment of flood impacts for forecasted and/or observed events, and 2) post flood assessments of Corps project benefit accomplishments. Analyses are performed by impact areas that include computing urban damage flood by categories, agricultural damage by crops, number of structures flooded by categories, area flooded, and population impacted. The seasonal variation in potential crop damage and effects of previous events are considered in the analyses. Results are displayed by impact areas, Corps Districts, states, Congressional Districts, counties, communities, and flood districts. Access to, control, and results visualization are via the control and Visualization Interface (CAVI) through its graphical representation of the watershed and river system.

Accomplishments and Outlook . . . . In FY 1999, Field Test Version 1.0 of the program has been undergoing testing. Version 1.0 user's manual was also prepared. The data has been tested on a variety of basins at the field test sites. Work in FY 2000 will focus on enhancing the GIS capabilities and links and provisions of added output results, warnings, and help messages.

System Integration, Implementation, and Management

This task provides standards for the development of components that will integrate with each other through database and control interfaces. Included are: a common scripting language across all products that will control execution; generalized messaging capability to permit processes to communicate with each other during their execution; libraries of shared functionality for use by multiple components; a programming environment that will provide flexibility in delivery of communication, database, modeling and graphic products in a changing hardware/software marketplace.

Accomplishments and Outlook . . . . In FY 1999, Field Test Version 1.0 was implemented and tested at the four field site has verified the flexibility of the underlying software architecture. Each major CWMS component was successfully installed, and configured. The directory naming structure is defined for use by all system components and modeling processes and is implemented at each site.

In FY 2000 the scripting language will be installed in the major CWMS components. The messaging system has been prototyped and will be made active. The alarm system will be implemented to provide active notification of data flow or other system anomalies.

Application of GIS and Image Technology

This work focuses on the unique capabilities that GIS can provide in improving to water-control decision making and operations, and hydraulic and hydrologic analysis. These objectives can be broken down into four areas: 1) visualization of GIS data, 2) integration of GIS and CWMS databases, 3) interpretation of remotely sensed images, and 4) implementation of RS/GIS tools.

Accomplishments and Outlook . . . . In FY 1999, in Field Test Version 1.0 GIS applications were successfully integrated into the CWMS pilot application. CorpsView was used to display map information and data held in the CWMS database. GIS-based programs generated inundation maps from HEC-RAS model results as part of the integrated CWMS system operated through the CWMS CAVI. In FY 2000, GIS activities for CWMS will include field support for the districts installing Test Version 2.0 of the CWMS, and continued development of GIS tools for use in the CWMS. Methods for using remote sensing data in model preparation will be developed. GIS integration with flood impact analysis will be improved.

Control and Visualization Interface

The Control and Visualization Interface (CAVI), oversees and controls the operation of the functional modules. It includes mechanisms for facilitating parameter adjustments, spatial and temporal visualization of observed and forecasted information, operation control of the modeling system, and an evaluation capability of pertinent information. The CAVI provides access to both the current observed states of the water system and the results from different forecast scenarios. Observed and forecasted information are displayed graphically, both in traditional two dimensional plots, and in spatial graphics, using schematic, map or photographic/image backgrounds.

Accomplishments and Outlook . . . . In FY 1999, a successful implementation of Test Version 1.0 was made in each of four filed test sites. Tests are being made of the mechanism for users to view current watershed conditions, modify modeling parameters, execute models, and view the results. Users identify basin locations for viewing graphs or tables of data for that location by selecting icons from a basin map using the mouse. In version 1.0 the primary focus has been on the modeling module. The modeling module is responsible for all activities associated with the computation of one or more forecast alternatives.

In FY 2000, the CAVI will be extended with improved model graphics, as well as, implementation of the data acquisition and data visualization modules. It will be able to be executed in a “client” mode on a different machine than where the models are run (i.e., the server), such as a PC running MS Windows while the server is on a Unix workstation. A major goal for Test Version 2.0 is providing practical user performance for client-server operations across a wide area net (CEAP).

Field Application Assistance

This provides field offices with assistance during the testing phase of the CWMS project. This task is further intended to provide assistance with hardware/system software advice. Assistance takes the form of implementation of software components at the four selected Corps test locations.

Accomplishments and Outlook . . . . In FY 1999, primary assistance was provided to the Baltimore District, Huntington District, Omaha District, and the NorthWestern Division. Each of the field test sites implemented the CWMS test version 1.0 software on their local systems. Support is furnished to WCDS field sites for each of the existing software products.

In FY 2000, the focus will be on implementation of test version 2.0 at the same four sites. In particular the testing of the client-server architecture across the CEAP wide area network is of most significant concern. It is possible that an additional client-server data base only test site will be implemented.

Training & Technology Transfer

The training activities of HEC are designed to increase the technical capabilities of the Corps field offices to meet needs and solve problems in hydrologic engineering and water resource planning. The training provides instruction in technical concepts and methods, and assists field offices in applying the methods to complex water resource problems and studies. This technology transfer is carried out through a variety of training courses and working sessions, with the emphasis on practical applications, using appropriate technology to solve real-world problems.

Training Programs

HEC training and technology transfer activities include the following:

- Training Courses
- Workshops designed to meet specific needs
- Seminars
- Professional Development Assignments
- Video Taped Lectures from Training Courses
- Technical Publications
- HEC Internet Homepage: www.hec.usace.army.mil
- Computer Software and Support

Recent activities are summarized below:

Training Courses

Recently, six courses are conducted each year under the Proponent Sponsored Engineers Corps Training (PROSPECT) Program. The HEC courses presented in FY 1999 and being offered in FY 2000 are shown in the following tables. Courses are usually one week in duration, and include formal lectures and practical problem-solving workshop sessions. Guest instructors from other Corps offices, universities and private industry are invited to participate. These instructors supplement the capabilities of the Center's staff.

HEC FY 1999 PROSPECT TRAINING PROGRAM

Course Title	Date	Length (weeks)	Number Students
Basic HEC-RAS	26 - 30 Oct 1998	1	24
Risk-based Analysis	16 - 20 Nov 1998	1	15
GIS – Hydrologic Engr	12 - 16 Apr 1999	1	30
Flood Hydrology with HEC-HMS	17 - 21 May 1999	1	31
Water and Watershed	12 - 16 Jul 1999	1	33
Groundwater Hydrology	16 - 20 Aug 1999	1	20
	TOTALS:	6	153

HEC FY 2000 PROSPECT TRAINING SCHEDULE

Course Title	Date	Length (weeks)	Number Students
Advanced HEC-RAS	24 – 28 Jan 2000	1	
GIS in Hydrologic Engineering	13 – 17 Mar 2000	1	
Basic HEC-HMS	8 – 12 May 2000	1	
Reservoir Analysis	19 – 23 Jun 2000	1	
Water & Watershed	17 – 21 Jul 2000	1	
River & Wetland Restoration	11 – 15 Sep 2000	1	
	TOTALS:	6	

Workshops

Workshops are conducted each year, on a reimbursable basis, at the request of individual district or division offices. The workshop may be similar in content to one of the regular courses, or it may focus on a particular need for which training is not available elsewhere. The duration of these workshops range from one day to one week. They are usually held at the requestor's office to allow greater participation by Corps office staff, as well as local, state and other federal agencies. During FY 1999, HEC conducted nine workshops for a total of 32.5 days of training and 159 students.

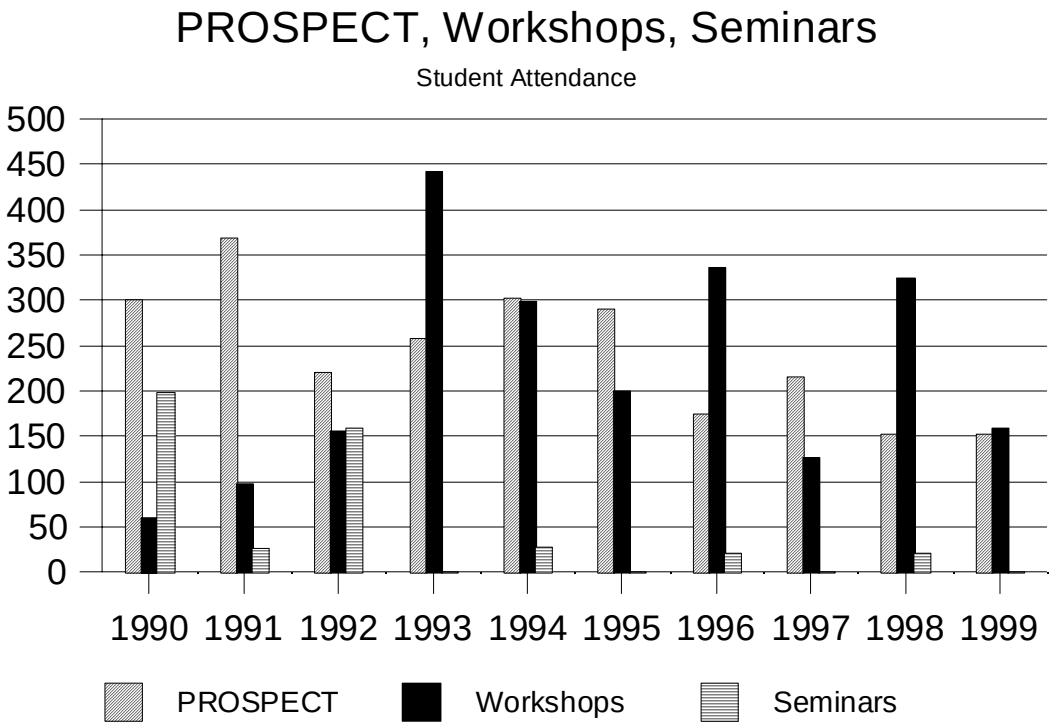
Seminars

Seminars provide a forum to discuss field problems and potential solutions, and to identify the need for new techniques. The papers presented by participants are

published as seminar proceedings. A seminar on "Risk-based Analysis - Lessons Learned" was held in FY 1998. There were no seminars during FY 1999.

Training Summary

A ten-year summary of attendance in courses, workshops and seminars is shown in the bar-chart below. High seminar attendance in 1990 and 1992 reflects the Water Quality Seminars HEC previously coordinated.



Professional Development

HEC initiated a formal Professional Development Program during FY 1992. The program provides broad training and work experience to candidates interested in hydrologic engineering and planning analysis methodologies. It provides an opportunity to participate in challenging studies in the Research, Technical Assistance, Training, and Planning Analysis Divisions. Selected candidates will investigate new techniques which, in many instances, have received only limited field application. Primary areas of interest include: watershed hydrology, river hydraulics, reservoir system analysis, statistical methods, and water resources planning studies involving risk and uncertainty, flood damage and plan formulation, and water management. An engineer from the Chicago District recently spent six months at HEC on a professional development assignment.

Video Tapes

Since 1974, HEC has made video tapes of selected training course lectures. The tapes are intended to supplement the training program by providing the course material to

those unable to attend courses. These tapes are available as recorded to Corps offices on request. Copies are available to all others for the cost of duplicating and mailing the tapes. Approximately 350 tapes are available, and the annual distribution varies from 100 to 400 tapes.

Technical Publications

HEC focuses a substantial portion of its resources on the development and documentation of applications software. Documentation includes user's manuals for the software, training documents, technical papers, research documents, project reports, and seminar proceedings. Many are placed on our web site; hundreds of copies of documents have been downloaded this past year. New and revised documentation issued during FY 1999 are listed below.

Computer Manuals

CPD-31	HEC-IFH, Interior Flood Hydrology Package, User's Manual, updated Jan. 1999.
CPD-75	HEC-GeoRAS, An Application for Support of HEC-RAS Using ARC/INFO, March 1999.

Project Reports

PR-36A	Mississippi Basin Modeling System - Operations Guide, April 1999
PR-38	Analysis of Flood Control Operation of the Iowa/Des Moines River Reservoir System Using Linear Programming Techniques, Jan. 1999.
PR-41	Development of HEC-FIA Models for the Phase I Sacramento and San Joaquin Rivers Basin Study, May 1999

Research Documents

RD-45	Resolving Conflict Over Reservoir Operation - A Role for Optimization and Simulation Modeling, June 1999.

A catalog of publications is available on request, and is on the HEC web page. HEC provides publications to Corps offices and places most publications into the National Technical Information Service (NTIS) system for general distribution. NTIS reference numbers are listed in the HEC Publications Catalog. Their address is: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; telephone (800) 553-6847, FAX (703) 605-6900. Additionally, HEC is placing computer program documentation and other documents on the HEC web site.

HEC Homepage

HEC has developed a WWW homepage (http://www.hec.usace.army.mil) to provide information and major computer programs and documents. Information is provided under six categories: HEC Organization, Visitor Information, Training Program, Publications, Software and What's New. Current copies of our Newsletter, Catalogs, and Annual Report are available to all. Corps offices may also keep up with HEC activities documented in the Quarterly Report. The NexGen computer programs and documents have been made available as they are released. Also, some of the earlier HEC programs

have been provided. Example usage for June 1999 shows an average of 4,093 file transfers per day. Daily requests range from 1,329 to 6,361. The majority of the requests were from the USA; however, foreign requests came from 56 countries, with over 1,000 requests coming from: Australia, Brazil, Canada, Germany, Spain, and Italy.

HEC Software

HEC has been developing computer programs for hydrologic engineering and planning analysis procedures since its inception in 1964. Software has evolved from computerized procedures to complex modeling systems. The software runs on PC-DOS compatible computers, UNIX workstations and Windows PC's. Executable PC programs are made available to non-Corps' offices through NTIS and a network of program vendors.

For the older PC-DOS programs, HEC has developed a package concept that provides more convenient application of batch processing programs. A menu provides for naming necessary program files, creating and editing input data with the COED software, running application program(s), and reviewing output with the LIST software. Once the files have been defined, the various programs can be executed directly from the menu. Additionally, COED can provide on-screen displays of program input requirements for each batch program. These on-screen displays are based on the input description provided in the associated user's manuals

The newer programs, like HEC-RAS, HEC-HMS, and HEC-FDA, are being developed for windows-based engineering workstations. HEC-RAS is a one-dimensional river hydraulics package designed to succeed HEC-2. The Hydrologic Modeling System (HEC-HMS) is a watershed model designed to succeed HEC-1, and the Flood Damage Analysis package will succeed the earlier multi-program package and includes risk and uncertainty in the analysis. At this time, HEC-RAS version 2.2, HEC-HMS version 1.1 and HEC-FDA version 1.0 have been released.

Software Library

The following is a list of the primary software, by technical subject. Brief descriptions and computer hardware/software requirements for the programs are contained in the Computer Program Catalog, which is available upon request, or on our homepage.

Numerical-Model Area	Primary Software
Hydrology	HEC-HMS, HEC-1
River Hydraulics	HEC-RAS, HEC-2, UNET, HEC-6
Analytical Planning	HEC-FDA, HEC-PBA
Statistical Methods	HEC-4, FFA, STATS
Reservoir Systems	HEC-5, HEC-PRM
Water Quality	HEC-5Q, WQRRS
Water Control	HEC-1F, DATCHK, DATVUE
Data Management	HEC-DSS, DSPLAY, DSSUTL
Interior Flood Hydrology	HEC-IFH

Software Support

Computer program support is designed to provide user assistance and to produce and distribute documentation for newly developed and improved software. Beginning in FY 1997, support for maintaining, documenting and distributing HEC software is funded directly via subscription fees from Corps offices. Accordingly, HEC only provides full program support and distribution to those subscribing offices. Other foreign and domestic government agencies, academic institutions, businesses, and private citizens may obtain the software from either the National Technical Information Service (NTIS) or vendors. Most software at NTIS is for use on MS DOS Personal Computers. Their address is: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; telephone (800) 553-6847, FAX (703) 605-6900. The cost includes software and documentation but does not include any technical support.

Vendors are public and private organizations that have obtained software from HEC and have agreed to distribute the current versions to requesters. The vendor determines fees for software and services. In additional to program distribution, many of the vendors provide user support and other services. Separate domestic (US) and foreign vendor lists are maintained by HEC and will be furnished upon request. Software not available from NTIS or vendors may be obtained directly from HEC.

Technical Assistance Projects

HEC's technical assistance program provides assistance and guidance to requesting Corps offices in the application of hydrologic engineering and water resources planning analysis techniques. Technical assistance activities are conducted on a cooperative and reimbursable basis. These activities enable HEC staff to maintain close contact with Corps personnel in district and division offices and to evaluate the effectiveness of new technology in a project application mode.

Each HEC division assists Corps offices in technical studies. The assistance varies from brief reviews of work done by others, functioning in an advisory role during the conduct of a study, to complex applications modeling involving a team of HEC and field office staff.

FY 1999 Accomplishments

FY 1999 technical assistance was $1,137,044. Assistance was provided to 14 Corps field offices, as well as, Headquarters (CECW), Institute for Water Resources (CEWRC-IWR), Cold Region Lab (CECRL), University of California, Davis (UCD), State of California and Metropolitan Water District of Southern California, Panama Canal Commission, and the National Institution for Building Sciences (NIBS).

Hydrologic Engineering Guidance Program

The initial draft of an Applications Guide for HEC-FDA, entitled "Risk-based Analysis for Flood Damage Reduction Studies" to assist Corps personnel in formulation and evaluation of flood damage reduction measures using risk-based analysis methods was completed during FY 1999. It will be an appendix to ER 1110-2-1619. Version 1.2 release of the HEC-FDA computer program is used to illustrate the analysis procedures in a real-study setting. The document will be completed during FY 2000.

Surface Water Hydrology

HEC's surface water hydrology technical assistance during the fiscal year covers a variety of topics. These include: arranging and participating in the Corps Hydrology Committee-sponsored seminar and meeting; flood warning-preparedness program assistance; snow and PMF studies; hydrologic impacts of coal mining; and assistance on several studies involving the new HEC-HMS applications. Also, new applications of geographic and terrain data were made for support of hydrologic modeling.

CECW	Headquarters: Civil Works Committee on Hydrology
CECER	Construction Engineering Lab: GIS for H&H Research
CELRN	Nashville District: GIS HEC-HMS for Cumberland River
CELRP	Pittsburgh District: Coal Mining Hydrology Impacts
CEMVP	St. Paul District: Devils Lake Stochastic Hydrology
CENWS	Seattle District: Green and Puyallup Rivers Modeling
CESAM	Mobile District: Flood Warning-Preparedness Program Assistance
CESPK	Sacramento District: Sacramento/San Joaquin Comprehensive Basin HEC-HMS Study

CESPL Los Angeles District: HEC-HMS Los Angeles Analysis, Alamo Dam Safety

Water Quality

HEC assisted CESPN, San Francisco District, with an analysis of dredging impacts on water quality in the San Francisco Bay.

Groundwater Hydrology

HEC continued its assistance to the Sacramento District in analyzing and modeling the Tooele Army Depot's pump-and-treat groundwater cleanup system.

Water Management

Assistance and consultation was provided HQUSACE in support of the Water Management mission. This included maintaining the Sun Solaris system at HQ, and support for the H&H Water Control/Quality web site. Direct on-site support was provided to the Lower Mississippi Valley Division office and the New Orleans District. These activities included loading software and configuring computer and network systems.

CESWA Albuquerque District: Development of Guidelines for numerical modeling
CESPK Sacramento District: Porting CWMS/Harris
CEMVD Mississippi Valley Division: CWMS Systems Support
CESWD Southwestern Division: CWMS Communications Assistance
HQUSACE Headquarters: CWMS Support

Reservoir Systems

Panama Canal Commission (PCC): The Canal Capacity Water Resource Evaluation, started near the end of FY 1998, provided a review of flow data development and developed reservoir models to evaluate the existing system and proposed alternatives. The flow data process was reviewed and HEC-DSS procedures were developed to automate the process. An HEC-5 reservoir system model was developed to evaluate the existing system. Tech-transfer workshops provided training on HEC-DSS and the HEC-5 software used in the evaluation. Additional HEC-5 models were developed for alternative evaluations. An HEC-PRM model was developed to assist in the study of alternative capacity expansion plans and a tech-transfer workshop was provided to PCC staff.
The HEC-RSS-LP Flood Control Linear Programming model was used in a Rock Island District study to evaluate reservoir flood control operations for the Iowa/Des Moines River system. It is also being applied to the Sacramento and San Joaquin reservoir systems as part of the Sacramento District's Phase I and Phase II Comprehensive Studies. HEC-5 reservoir simulation models were also developed for more detailed study of the two systems. The HEC-RSS-LP and HEC-5 models will be calibrated using several recent floods and then utilized to evaluate alternative operations schemes.

Support to the Mobile District continued in the application of the HEC-5 model to the ACT/ACF Study. System models for the existing system, under several operational scenarios were completed and documented.

CEMVR	Rock Island District: Iowa River Basin Reservoir Operations
CESAM	ACT/ACF Comprehensive Water Resource Evaluations were completed.
CESPK	Sacramento District: Sacramento and San Joaquin Basins Comprehensive Study.
PCC	Panama Canal Commission: Canal Capacity Water Resource Evaluation.
CENWD	Cumberland River Hydropower evaluation with HEC-5.
CESAC	Pee Dee River HEC-5 Model update and review.

River Hydraulics

HEC-RAS computer program was modified for the Los Angeles District to provide side-weir overflow modeling and to balance flow distribution in divided flow networks. These features were required for District flood studies and they will be available to the public with the release of Version 3 of HEC-RAS. With support from FPMS, HEC developed new HEC-RAS course materials and a paper on HEC-GeoRAS ability to develop 3-D terrain data for modeling and to perform inundation mapping. The paper was presented at the Association of State Flood Plain Managers Conference. The HEC-RAS and GeoRAS program features were applied to evaluate alternatives to maintain Riverine habitat downstream from Seven Oaks Dam.

CECW	Headquarters: Flood Plain Management Services (CEFPMS). Model documentation updates.
CESPL	Los Angeles District: Add program features to HEC-RAS. Model Santa Ana River below Seven-Oaks Dam to evaluate riverine habitat.
CEMVS	St. Louis District: Mississippi River Basin UNET Modeling. HEC continued to provide support for the implementation of the UNET models for river operations. A report on the project and a program application guide were written to document the UNET system operation.
CESWG	Galveston District: UNET model review for the District.
CESPK	Sacramento District: Update of HEC-RAS floodplain model to incorporate new data.
CECW	Headquarters: Mississippi River Basin UNET Modeling. HEC continued to provide support for the implementation of the UNET models for river operations. Assistance was provided in obtaining, analyzing, and using new digital terrain data for cross-section, river, and floodplain geometry. (just one part Tom did of the overall effort - see full P00-004 series)

Flood Damage

HEC is developing methods to better analyze and communicate the residual risk associated capacity exceedance events of flood damage reduction projects. HEC is assisting the Sacramento and Rock Island districts in preparing HEC-FIA models of the Sacramento and San Joaquin basins, and Iowa and Des Moines river systems, respectively. Other flood damage analysis assistance projects include the applications of HEC-FDA to the Tres Rios and Anacostia rivers systems.

CECW	Headquarters: Residual Risk Methods Invesigation
CESPL	Los Angeles District: Tres Rios Constructed Wetlands and HEC-FDA Flood Analyses
CECW	Headquarters: Residual Risk Assessment and Communication
CESPK	Sacramento District: Sacramento and San Joaquin Phase I and II Comprehensive Study HEC-FIA Modeling

CEMVR	Iowa and Des Moines Rivers HEC-FIA modeling assistance
CENAB	Anacostia River HEC-FDA modeling

Statistics

The major review of the Upper Mississippi River System flood frequency relationships continues for the Rock Island District. An investigation of the appropriate flood frequency estimation methodology was performed by analyzing unregulated flow estimates for the major drainage areas. A Federal Interagency and Technical Advisory Group to the Corps of Engineers reviewed recommendations from the analysis. HEC provided technical analyses and supported the Sacramento District in the review of the American River Flood Frequency study by the National Research Council.

CECRL	Cold Regions Lab: Ice Jam and Flow Frequency below Oahe Dam, SD
CEMVR	Rock Island District: Upper Mississippi System Flood Frequency, Des Moines River Regulated Flood Frequency
CESPK	Sacramento District: National Research Council Review of the American River Flood Frequencies, Friant Dam Regulated Frequency Curve

Software Development Assistance

Software development enhancements were added to the HEC-RAS model during FY 1999. A new utility program was written to convert HEC-RAS terrain data into an HEC-UNET CSECT input data file. This allows the District to develop and calibrate their geometric data using HEC-RAS and then transfer the data to use with UNET. The utility program will be distributed with version 2.2 of HEC-RAS. A utility program was developed for the Vicksburg District to translate survey data format into a format HEC-RAS could import.

CESPK	Sacramento District: UNET geometry data from HEC-RAS
CEMVK	Vicksburg, District: Develop data translation program to import survey data into HEC-RAS
UCD	University of California, Davis: Enhancements to HEC-PRM for CalFed Study MWD, Delta Simulation Model
CECER	Construction Engineering Lab: Participate in Land Management System Development Team
CECHL	Coastal and Hydraulics Lab: Land Management System Review Relative to Corps Water Management System

FRONT ROW *(Left to Right)*:
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